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Indian Standard
SPECIFICATION FOR ALUMINIUM CASTING ALLOY INGOTS AND CASTINGS FOR AIRCRAFT PURPOSES
(Third Revision)

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NEW DELHI 110002

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Indian Standard

SPECIFICATION FOR ALUMINIUM CASTING ALLOY INGOTS AND CASTINGS FOR AIRCRAFT PURPOSES

(Third Revision)

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Indian Standard

SPECIFICATION FOR ALUMINIUM CASTING ALLOY INGOTS AND CASTINGS FOR AIRCRAFT PURPOSES

(Third Revision)

0. FOREWORD

0.1 This Indian Standard (Third Revision) was adopted by the Indian Standards Institution on 16 December 1981, after the draft finalized by the Light Metals and Their Alloys Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 In this standard, a few more new casting alloys which are now being used extensively for aircraft components have been incorporated together with alloy designation No. as per IS : 6051-1970*. Also, conventional unit for tensile strength has been changed to MPa with proof stress values on 0·2 percent strain against 0·1 percent.

0.2.1 Further, a list of near-equivalent material specifications of British, American, French, German and Russian origin are provided for reference. Heat treatment parameters for each alloy have also been indicated as a guidance for the heat-treaters. In addition to this, the general characteristics of different casting alloys are given in Appendix A.

0.3 In the formulation of this revision, due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in India. This has been met by deriving assistance from the following publications:

CSA HA Series — 1958 Specification for aluminium and aluminium alloys. Canadian Standards Association.

BS 4L 33 : 1959 Aluminium — silicon alloy ingots and castings. British Standards Institution.

BS 4L 35 : 1970 Aluminium — copper alloy ingots and castings. British Standards Institution.

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*Code for designation of aluminium and its alloys.

BS 3L 51 : 1970 Aluminium-silicon — copper-iron ingots and castings. British Standards Institution.

BS 4L 53 : 1970 Aluminium — magnesium alloy ingots and castings. British Standards Institution.

BS L 75 : 1959 Aluminium — silicon alloy ingots and castings. British Standards Institution.

BS 2L 91 : 1970 Aluminium — copper alloy ingots and castings. British Standards Institution.

BS 2L 92 : 1970 Aluminium — copper alloy ingots and castings. British Standards Institution.

DTD 5018 : 1965 Aluminium — magnesium-zinc alloy ingots and castings. Aircraft Material Specification. Ministry of Aviation, UK.

AIR 3380 Aircraft material specification. Ministry of Air Force, France.

DIN 1725 : 1973 Deutsche Industrie Normen, West Germany.

QQ-A 596 and 601 : Federal aircraft material specification, USA.

GOST : 2685 Russian specification.

0.4 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the specific requirements for each of the aluminium base alloy ingots and castings (depending on the method of manufacture) for aircraft purposes.

2. MATERIAL

2.1 General requirements relating to the supply of aluminium casting alloy ingots and castings for aircraft purposes shall be as laid down in IS : 1387-1967†.

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*Rules for rounding off numerical values (*revised*).

†General requirements for the supply of metallurgical materials (*first revision*).

3. INSPECTION

3.1 Ingots and castings shall be inspected in accordance with the relevant requirements of IS : 2304-1962*.

4. MANUFACTURE

4.1 Casting Alloy Ingots — Aluminium used in making alloys shall conform to the requirements of primary ingots as specified in IS : 23-1980† and secondary ingots as specified in IS : 3435-1968‡.

4.2 Castings shall be manufactured from ingots conforming to the appropriate chemical requirements of this specification or by direct alloying at the discretion of the manufacturer.

4.3 No scrap shall be used other than that derived from the maker's own material manufactured to this specification.

4.4 Radiographic Examination — All aluminium and aluminium alloy castings may be subject to radiographic examination if specifically agreed to between the purchaser and the supplier. The standard of acceptance of castings on the basis of radiographic examination shall also be subject to mutual agreement between the purchaser and the supplier.

5. CHEMICAL COMPOSITION

5.1 The chemical composition of ingots and castings when analyzed in accordance with IS : 504-1963§ shall conform to the requirements given in Table 1.

6. CONDITION

6.1 Castings shall be supplied in appropriate conditions shown below depending on alloy composition:

M — As-cast
W — Solution treated and naturally aged
P — Only artificially aged
WP — Solution treated and precipitation treated
WS — Solution treated and stabilized.

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*Procedure for inspection and testing of light metals (aluminium and magnesium) and their alloy ingots and castings for aircraft purposes.

†Specification for primary (virgin) aluminium notched bars and ingots for remelting for aircraft purposes (*third revision*).

‡Specification for 99 percent secondary aluminium notched bars and ingots for remelting for aircraft purposes.

§Methods of chemical analysis of aluminium and its alloys (*revised*).

7. HEAT TREATMENT

7.1 Heat treatment of the castings, if any, shall be carried out by the manufacturer so as to achieve the desired strength properties. The heat treatment parameters in Table 1 for the different alloys are found capable of achieving the desired properties and are given as a guidance only.

8. MECHANICAL PROPERTIES

8.1 The mechanical properties obtained from separately cast samples selected and prepared in accordance with the relevant requirements of IS : 2304-1962* and tested in accordance with IS : 1816-1979† shall be not less than the values given in Table 1.

8.2 In the event of separately cast test bars being not available, the following procedure may be adopted for acceptance.

8.2.1 The properties shall be determined on three test specimens taken from the thickest and thinnest and intermediary sections of a casting selected by the inspecting authorities and shall meet unless otherwise specified by the purchaser or on contract, a minimum of 80 percent of proof stress and tensile strength values and a minimum of 50 percent of elongation specified for separately cast test bars.

9. FRACTURE TEST

9.1 If such testing is to be used in addition to radiography inspection, fracture test shall be carried out if required by the customer to ascertain uniformity of grain size, freedom from microshrinkages and other gross casting defects.

10. PRESSURE TEST

10.1 When required by the customer, pressure test shall be carried out as detailed in the drawing/schedule.

11. IDENTIFICATION

11.1 Ingots — All ingots approved by the inspector shall be identified by the mark of the inspector and Melt No., Specification No., etc, so as to ensure full identification of the material.

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*Procedure for inspection and testing of light metals (aluminium and magnesium) and their alloy ingots and castings for aircraft purposes.

†Tensile test for light metals and their alloys (*first revision*).

11.2 Castings — All casting 2·5 kg each in weight and over, approved by the inspector, shall be stamped with the mark of the inspector along with Part No., Melt No., Specification No., Heat No., etc, so as to ensure full identification of the material. All markings shall be made at a location indicated in the drawing or in its absence, at places specified by the inspecting authority (that is, where they are least liable to be detrimental to the casting in its service).

11.2.1 *Casting Under 2·5 kg* — All castings, less than 2·5 kg each in weight, approved by the inspector, shall be made into parcels which shall bear a tag with the mark of the inspector along with Part No., Melt No., Specification No., Heat No., etc, so as to ensure full identification of the material.

12. CERTIFICATION

12.1 All ingots and castings shall be accompanied by certification by person or persons approved by the inspecting authority for freedom from defects, radiographic test, chemical composition, heat treatment, mechanical properties, as laid down in 3, 4, 5, 7 and 8 respectively or as required by the inspecting authority.

12.2 The manufacturer shall maintain all records pertaining to each melt of the alloy and when required, supply free of charge a copy of works analysis of the material and other details whenever required by the inspecting authority. (Work analysis is defined as routine analysis conducted by the manufacturer in order to control the quality of the material.)

13. CORROSION PREVENTION

13.1 The approved and identified castings shall be coated with suitable temporary coatings, such as 'lanolin' before transit or storage.

AMENDMENT NO. 1 APRIL 1994
TO
IS 202 : 1981 SPECIFICATION FOR ALUMINIUM CASTING ALLOY INGOTS AND CASTINGS FOR AIRCRAFT PURPOSES

(Third Revision)

(*Page* 9, *Table* 1, *col* 1) — Substitute '4450' *for* '4458'.

(*Page* 11, *Appendix* A, *col* 1) — Substitute '4450' *for* '4458'.

(MTD 7)

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TABLE 1 CHEMICAL COMPOSITION, MECHANICAL PROPERTIES OF CASTINGS ALONG WITH HEAT-TREATMENT DETAILS, CONDITION, ALLOY DESIGNATION AND NEAR EQUIVALENT SPECIFICATION

(*Clauses* 5.1, 7.1 *and* 8.1)

ALLOY DESIGNATION	ALLOY NOMENCLATURE	NEAR EQUIVALENT SPECIFICATION	CHEMICAL COMPOSITION PERCENT, VALUES GIVEN ARE MAXIMUM, UNLESS OTHERWISE SHOWN												CONDITION	MECHANICAL PROPERTIES				METHOD OF CASTING	HEAT TREATMENT
			Cu	Mg	Si	Fe	Mn	Ni	Zn	Pb	Sn	Ti &/or Nb	Others	Al		PS (MPa)	TS (MPa)	Elongation on 5·65$\sqrt{A}$, Percent	Hardness (HB)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
2285	Al-4% Cu Ni Mg Alloy	(A 14) BS L35 AU4NT (AIR 3380) Al 1G 2685	3·5-4·5	1·2-1·8	0·60	0·60	0·60	1·8-2·3	0·10	0·05	0·05	0·25	Si + Fe 1·0	Remainder	W	210 230	220 280			SC CC	Solution. 510 ± 10°C for 6 h. Quench in oil/water air. Age 5 days (*Min*) or 100 ± 5°C for 2 h
2280	Al-4·5% Cu Ti Alloy	(A11) (A 25) BS L91 BS L92 AL 7 G2685 295 (QQ-A-601) Cl·4	4·0-5·0	0·10	0·25	0·25	0·10	0·25	0·10	0·05	0·05	0·05-0·30		„	WP† WP	165 165 200 200	220 265 280 310	7 3 4 9		SC CC SC CC	Solution. 535 ± 10°C for 12 h. Quench in water/oil. Precipitation at 130 ± 10°C for 1-2 h Solution. 535 ± 10°C for 12 h. Quench in water/oil. Precipitation at 120-170°C for 6-8 h
2258*	Al-4·5% Cu Mg Ti Alloy	AU 5GT (AIR 3380) 3·1371 (DIN 1725) G Al Cu4 TiMg Ka G Al Cu4 TiMg Wa GK-Al Cu4 TiMg Ka GK-Al Cu4 TiMg Wa	4·0-5·0	0·15-0·35	0·30	0·30	0·10	0·03				0·17-0·35		„	W	195 215	315 335	7 7	85 85	SC DC	Solution. 530°C Quench in water, Age 4 days
2838	Al-5% Cu Ni Mn Sb Co Zr Alloy	MSRR 8009 BSEM 558, BACE 411, RR/MS 515 MSRR 8010 MSRR 8040	4·5-5·5		0·30		0·20-0·30	1·3-1·8				0·15-0·25	Zr 0·10-0·30 Co Sb Co+Sb 0·10- 0·10- 0·60 0·40 0·40	„	WP	190	215			SC	Solution. 537-547°C for 5 h. Quench in boiling water. Precipitation at 215-220°C for 16 h, cool in air
4128	Al-2·5% Si Cu Fe Ni Mg Alloy	BS L51 AS2UN (AIR 3380)	0·80-2·0	0·05-0·20	1·5-2·8	0·80-1·4	0·10	0·80-1·7	0·10	0·05	0·05	0·25		„	P	125 140	160 200	2 3		SC CC	Precipitation at 150-175°C for 8-24 h
4223	Al-5% Si Cu Mn Alloy	(A4) BS L79	2·0-4·0	0·15	4·0-6·0	0·80	0·30-0·70	0·30	0·50	0·1	0·05	0·20		„	M	85 (0·1 % PS) 90 (0·1 % PS)	140 150	2 2		SC CC	Usually no heat-treatment required. Annealing at 250-350°C for 4 h. Air-cool slowly
4320*	Al-6% Si Cu Alloy	319 (QQ-A-601) Cl.18 319(QQ-A-596) Cl.11	3·0-4·0	0·10	5·5-6·5	0·10	0·50	0·35	1·0	—	—	0·25	0·50 (others total)	—	WP	135	220	2·5 1 (on 50 mm) 1 (on 50 mm)	80	SC	Solution. 504 ± 6°C for 6-12 h precipitation at 157 ± 6°C for 3-5 h
4458	Al-7% Si Mg Alloy	(A 27) L99, DTD 5028 3.2371 (DIN 1725) G-Al Si 7 Mg Wa GK-AlSi 7 Mg Wa	0·10	0·20-0·45	6·5-7·5	0·20	0·10	—	0·10	0·10	0·05	0·20			WP	185 (0·1 % PS) 200 (0·1 % PS)	230 280	2 5		SC CC	Solution 540 ± 5°C for 12 h (*Min*). Quench in hot water, temp 65°C precipitation at 155 ± 5°C for 4 h minimum and oil-cool
4425	Al-7·8% Si Cu Alloy	328 (QQ-A 601) Cl.20	1·0-2·0	0·20-0·60	7·0-8·6	1·00	0·20-0·60	0·25	1·5			0·25	0·50 (others total) Cr 0·35		M WP	95 145	170 235	1 (on 50 mm) 1 (on 50 mm)	60 85	SC SC	Solution. 504 ± 6°C for 8-12 h. Precipitation at 154 ± 6°C for 3-5 h

(*Continued*)

TABLE 1 CHEMICAL COMPOSITION, MECHANICAL PROPERTIES OF CASTINGS ALONG WITH HEAT-TREATMENT DETAILS, CONDITION, ALLOY DESIGNATION AND NEAR EQUIVALENT SPECIFICATION — *Contd*

ALLOY DESIGNATION	ALLOY NOMENCLATURE	NEAR EQUIVALENT SPECIFICATION	CHEMICAL COMPOSITION, PERCENT, VALUES GIVEN ARE MAXIMUM, UNLESS OTHERWISE SHOWN												CONDITION	MECHANICAL PROPERTIES				METHOD OF CASTING	HEAT TREATMENT
			Cu	Mg	Si	Fe	Mn	Ni	Zn	Pb	Sn	Ti &/or Nb	Others	Al		PS (MPa)	TS (MPa)	Elongation on 5·65$\sqrt{A}$, Percent	Hardness (HB)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
4420	Al-3·5% Si Cu Alloy	(A24) A380 (QQ-A-591) Alloy 380	3·0-4·0	0·10	3·5-9·5	1·3	0·50	0·50	1·0		0·30		0·50 (others total)	Remainder	M	160	325	(on 50 mm 3·5) (on 50 mm)		DC SC	
4585*	Al-9% Si Mg Co Alloy	AS9KG (AIR 3380)	0·10	0·17-0·25	8·8-9·7	0·60	0·03						Co 0·35-0·55 (others total 0·20)	"	WP	155 165	235 245	3 3	80 85	DC	Solution. 530±5°C. Quench in water. Precipitation at 150°C for 33 h
4535*	Al-9·5% Si Mg Mn Alloy	AS10G (AIR 3380)	0·10	0·17-0·35	8·9-10·1	0·65	0·25-0·50	0·03					Co 0·20 (others total 0·20)	"	M WP M WP	95 175 110 185	155 235 185 255	3·5 1 2 1	55 80 65 85	SC SC DC DC	Solution. 540±5°C. Quench in water. Precipitation at 175°C for 10 h
4600	Al-11·5% Si Alloy	(A-6) BSL 33	0·10	0·10	10·0-13·0	0·60	0·50	0·10	0·10	0·10	0·05		—	"	M	55 (0·1% PS) 69 (0·1% PS)	160 185	5 7		SC CC	Usually no heat-treatment required Annealing: 280-350°C for 2-4 h
4635	Al-11·5% Si Mg Mn Alloy	(A-9) BSL 75	0·10	0·20-0·60	10·0-13·0	0·60	0·30-0·70	0·10	0·10	0·10	0·05	0·20	—	"	WP	200 (0·1% PS) 245(0·1% PS)	240 295			SC CC	Solution. 525±3°C. Quench in water. Precipitation at 169±3°C for 20 h. Stress relieve at 280°C for 10 h
4700	Al-13% Si Alloy	AS 13 (AIR 3380)	0·10	0·10	12·0-13·7	0·75	0·10	0·03					Co 0·20 (others total 0·20)	"	M	80 80	165 175	4 3	50 60	SC DC	
5200*	Al-4% Mg Alloy	514·0 (QQ-A-01) C1 5	0·15	3·5-4·5	0·35	0·50	0·35	0·10	0·15			0·25	0·15 (Each 0·05)	"	M	60	150	6	50	SC	
5438	Al-7·7% Mg Zn Alloy	DTD 5018A	0·20	7·4-7·9	0·25	0·35	0·1-0·3	0·10	0·9-1·4	0·05	0·05	0·25	—	"	W	170 170	280 310	5 10		SC CC	Solution. 430 ± 5°C for 8 h (*Min*). Quench in oil at 160°C (*Max*). Solution 440 ± 5°C for 8 h (*Min*), then raise the temperature to 495 ± 5°C and hold for 8 h (*Min*). Quench in oil at 160°C. (Casting shall not remain in the oil for more than 1 h and then quench in oil at room temp or cool in air)
5500	Al-10% Mg Alloy	(A-10) BSL-53 3·3591 43 (DIN 1725) (G-Al Mg 10 ho) Al-8G 2685	0·10	9·5-11·0	0·25	0·35	0·10	0·10	0·10	0·05	0·05	0·20	-	"	W	170 170	280 310	8 12		SC CC	Solution. 430 ± 5°C for 8 h (*Min*). Quench in oil at 160°C (*Max*) and hold 1 h (*Max*). Furnace cooling at 390 ± 5°C permissible before quenching in hot oil

NOTE 1 — Chemical composition of ingots almost similar to those of castings, except for some very minor deviation in Mn, Zn, Tin, Lead in some cases.

NOTE 2 — Mechanical properties are minimum unless indicated otherwise.

NOTE 3 — Proof stress values are given on 0·2% strain unless indicated otherwise.

NOTE 4 — Specification in bracket under col 3 denotes old alloy designation.

NOTE 5 — The casting and test samples shall be heat treated together.

*Denotes ' new alloy'.

†Solution heat treated condition, but reheated to 130 ± 10°C for 0-2 h for improved properties.

APPENDIX A

(*Clause* 0.2.1)

Alloy Designation	Castability	Corrosion Resistance	Machinability	Weldability	Pressure Tightness	Typical Uses/Characteristics
2285	Good; unsuitable for pressure die casting	Fair	Good	Poor	Fair	Historically known as 'Y' alloy, has the capability of maintaining strength and hardness at high temperature and with its good machinability characteristics, this alloy is suitable for engine piston cylinder. It is sensitive to hot cracking when gravity die-cast. The alloy is prone to acid formation and intercrystalline shrinkage. Maximum service temperature 300°C
2280	Fair for sand casting; poor, unsuitable for gravity die and pressure die casting	Fair	Good	Poor (Fair for non-heat treated alloys)	Poor	In the fully heat treated condition, it possesses high strength and good ductility. Mainly used for applications where high strength and machinability are required. It has got tendency to hot cracking while casting. Maximum service temperature 350°C
2838	Fair for sand casting	Fair	Good	Fair	Fair	Used for high temperature application, such as delivery casing
4128	Good; unsuitable for pressure die casting	Good	Fair	Good	Good	A general purpose alloy, but often used in aircraft structural members requiring medium strength and in pump systems where pressure tightness is an important criterion
4223	Good	Good	Good	Good	Good	Medium strength combined with good casting properties. Also a general purpose alloy used for wide variety of castings
4458	Excellent	Good	Good	Good	Good	Used for applications where excellent castability, good weldability, pressure tightness and resistance to corrosion are required. Also provides tensile strength and ductility. It can be cast in sand mould, gravity die and low pressure die casting method
4420	Excellent for pressure die castings (Fair for sand and gravity die castings)	Good	Fair	Unsuitable	Good	Pressure die castings for engine component.

(*Continued*)

APPENDIX A — *Contd*

ALLOY DESIGNATION	CASTABILITY	CORROSION RESISTANCE	MACHINABILITY	WELDABILITY	PRESSURE TIGHTNESS	TYPICAL USES/CHARACTERISTICS
4585	Excellent	Good	Good	Good	Good	Used for aircraft components, such as flange, vent flange
4535	Excellent	Good	Good	Good	Good	Used for aircraft components, such as drive casing, front casing
4600	Excellent (Good for pressure die casting)	Good	Good	Excellent	Excellent	One of the most widely used alloys for general engineering purposes, suitable for sand, gravity die and pressure die casting. Possesses excellent foundry characteristics, including exceptional fluidity. It has good corrosion resistance and medium strength, suitable for casting intricate patterns
4635	Excellent	Good	Good	Good	Excellent	It has excellent castability and resistance to chemical attack as well as good machining and welding characteristics. This alloy responds to heat treatment and it is one of those few alloys which could be artificially aged without prior solution heat treatment to improve mechanical properties. The pressure tightness and dimensional stability on temperature variations of this alloy are used to advantage in the automotive and aircraft industries
5438						A special purpose alloy designed for particular high strength aircraft application. Its casting by sand and gravity die casting methods requires keen attention
5500	Fair (Unsuitable for pressure die casting)	Excellent	Good	Good	Poor	This alloy when treated (solution heat treat only) combines the highest mechanical properties and the best corrosion resistance and machinability.

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†Western : Manakalaya, E9, Behind Marol Telephone Exchange, Andheri (East), MUMBAI 400093	832 92 95

Branch Offices::

'Pushpak', Nurmohamed Shaikh Marg, Khanpur, AHMEDABAD 380001	550 13 48
‡Peenya Industrial Area, 1st Stage, Bangalore-Tumkur Road, BANGALORE 560058	839 49 55
Gangotri Complex, 5th Floor, Bhadbhada Road, T.T. Nagar, BHOPAL 462003	55 40 21
Plot No. 62-63, Unit VI, Ganga Nagar, BHUBANESHWAR 751001	40 36 27
Kalaikathir Buildings, 670 Avinashi Road, COIMBATORE 641037	21 01 41
Plot No. 43, Sector 16 A, Mathura Road, FARIDABAD 121001	8-28 88 01
Savitri Complex, 116 G.T. Road, GHAZIABAD 201001	8-71 19 96
53/5 Ward No.29, R.G. Barua Road, 5th By-lane, GUWAHATI 781003	54 11 37
5-8-56C, L.N. Gupta Marg, Nampally Station Road, HYDERABAD 500001	20 10 83
E-52, Chitaranjan Marg, C-Scheme, JAIPUR 302001	37 29 25
117/418 B, Sarvodaya Nagar, KANPUR 208005	21 68 76
Seth Bhawan, 2nd Floor, Behind Leela Cinema, Naval Kishore Road, LUCKNOW 226001	23 89 23
Patliputra Industrial Estate, PATNA 800013	26 23 05
T.C. No. 14/1421, University P. O. Palayam, THIRUVANANTHAPURAM 695034	6 21 17

Inspection Offices (With Sale Point) :

Pushpanjali, 1st Floor, 205-A, West High Court Road, Shankar Nagar Square, NAGPUR 440010	52 51 71
Institution of Engineers (India) Building 1332 Shivaji Nagar, PUNE 411005	32 36 35

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*Sales Office is at 5 Chowringhee Approach, P.O. Princep Street, CALCUTTA 700072	27 10 85
†Sales Office is at Novelty Chambers, Grant Road, MUMBAI 400007	309 65 28
‡Sales Office is at 'F' Block, Unity Building, Narashimaraja Square, BANGALORE 560002	222 39 71

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